

variations as fall within the broad scope of the appended claims.

WHAT IS CLAIMED IS:

1. A nickel base superalloy comprising 3.0 to 12 wt% chromium, up to 3.0 wt% molybdenum, 3.0 to 10 wt% tungsten, up to 5.0 wt% rhenium, 6.0 to 12 wt% tantalum, 4.0 to 7.0 wt% aluminum, up to 15 wt% cobalt, up to 0.05 wt% carbon, up to 0.02 wt% boron, up to 0.1 wt% zirconium, up to 0.8 wt% hafnium, up to 2.0 wt% niobium, up to 1.0 wt% vanadium, up to 0.7 wt% titanium, up to 10 wt% of at least one element selected from the group consisting of ruthenium, rhodium, palladium, osmium, iridium, platinum, and mixtures thereof, and the balance essentially nickel, said nickel base superalloy having a microstructure which is pore-free and eutectic  $\gamma - \gamma'$  free.

2. A nickel base superalloy according to claim 1, wherein said microstructure has a gamma prime morphology which includes a bimodal  $\gamma'$  distribution.

3. A nickel base superalloy according to claim 2, wherein said bimodal  $\gamma'$  distribution includes a uniform distribution of large  $\gamma'$  precipitates in a continuous gamma matrix and a second and uniform distribution of fine  $\gamma'$  particles.

4. A nickel base superalloy according to claim 3, wherein said large  $\gamma'$  particles are octet shaped and have an average particle size in the range of  $1.0\mu$  to  $20\mu$  and the fine  $\gamma'$  particles are cuboidal particles and have an average particle size in the range of from  $0.45\mu$  to  $0.55\mu$ .

5. A nickel base superalloy according to claim 1, wherein said nickel base superalloy is a single crystal nickel base superalloy.

6. A single crystal nickel base superalloy having a microstructure which is pore-free and eutectic  $\gamma - \gamma'$  free and which has a gamma prime morphology which includes a bimodal  $\gamma'$  distribution.

7. A single crystal nickel base superalloy according to claim 6, wherein said bimodal  $\gamma'$  distribution includes large  $\gamma'$  particles having a particle size in the range of from  $1.0\mu$  to  $20\mu$  and fine  $\gamma'$  particles.

8. A single crystal nickel base superalloy according to claim 7, wherein said large  $\gamma'$  particles are present in an amount from 25 vol% to 50 vol%.

9. A single crystal nickel base superalloy according to claim 7, wherein said large  $\gamma'$  particles are present in an amount from 27 vol% to 45 vol%.

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a2 } 10. A single crystal nickel base superalloy according to claim 7, wherein said fine  $\gamma'$  particles have a particle size in the range of from  $0.45\mu$  to  $0.55\mu$ .

11. A single crystal nickel base superalloy according to claim 7, wherein said large  $\gamma'$  have an octet shape and said fine  $\gamma'$  particles have a cuboidal shape.

casting an object formed from a single crystal nickel base  
superalloy having a microstructure;

fully solutioning any eutectic  $\gamma - \gamma'$  phase and precipitating a uniform distribution of large  $\gamma'$  particles in the microstructure; and

13. A process according to claim 12, wherein said casting step comprises casting a single crystal nickel base superalloy having a composition comprising 3.0 to 12 wt% chromium, up to 3.0 wt% molybdenum, 3.0 to 10 wt% tungsten, up to 5.0 wt% rhenium, 6.0 to 12 wt% tantalum, 4.0 to 7.0 wt% aluminum, up to 15 wt% cobalt, up to 0.05 wt% carbon, up to 0.02 wt% boron, up to 0.1 wt% zirconium, up to 0.8 wt% hafnium, up to 2.0 wt% niobium, up to 1.0 wt% vanadium, up to 0.7 wt% titanium, up to 10 wt% of at least one element selected from the group consisting of ruthenium, rhodium, palladium, osmium, iridium, platinum, and mixtures thereof, and the balance essentially nickel.

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of from 2145°F to 2625°F for a time period in the range of from 3.5 hours to 4.5 hours at a final pressure in the range of from 13 ksi to 16.5 ksi.

15. A process according to claim 14, wherein said hot isostatic processing step is carried out at a final temperature in the range of 2195°F to 2565°F and at a final pressure in the range of from 14 ksi to 16 ksi.

16. A process according to claim 14, wherein said hot isostatic processing step further comprises bringing the cast object from room temperature to a first temperature in the range of from 2075°F to 2550°F at a rate of from about 5.4 to 6.6°F/min, from the first temperature to a second temperature in the range of 2125°F to 2595°F at a rate of from 0.4 to 0.6°F/min, and from the second temperature to the final temperature at a rate of 0.05°F/min to 0.15°F/min.

17. A process according to claim 14, wherein said hot isostatic processing step further comprises bringing the cast object from room temperature to a first temperature in the range of 2115°F to 2485°F at a rate of from 5.5 to 6.5°F/min., from the first temperature to a second temperature in the range of from 2170°F to 2550°F at a rate in the range of from 0.45 to 0.55°F/min, and from the second temperature to the final temperature.

18. A process according to claim 14, wherein said hot isostatic processing step further comprises raising the pressure from substantially 0 psi to a first pressure in the range of from 4.5 to 5.5 ksi at a rate in the range of 0.01 ksi/min and then raising the pressure from the first pressure to the final pressure at a rate in the range of 0.03 ksi/min. and holding the

final pressure for a time period in the range of from 2.5 hours to 3.5 hours.

19. A process according to claim 12, wherein said fully solutioning and precipitating step comprises subjecting the cast object to a solution heat treatment step.

20. A process according to claim 19, wherein said solution heat treating step comprises bringing the cast object from room temperature to an initial temperature in the range of from 1625°F to 2000°F at a temperature ramp rate in the range of from 30°F/min. to 40°F/min., taking the cast object from the initial temperature to a second temperature in the range of from 2075°F to 2525°F at a temperature ramp rate in the range of 7.5°F/min. to 9.0°F/min., taking the cast object from the second temperature to a third temperature in the range of from 2100°F to 2575°F at a temperature ramp rate in the range of 1.0°F/min. to 2.0°F/min., taking the cast object from the third temperature to a fourth temperature in the range of 2130°F to 2600°F at a temperature ramp rate in the range of from 0.9°F/min. to 1.1°F/min., taking the cast object from the fourth temperature to a fifth temperature in the range of from 2145°F to 2625°F at a temperature ramp rate in the range of from 0.4°F/min. to 0.6°F/min., taking the cast object from the fifth temperature to a sixth temperature in the range of from 2150°F to 2650°F at a temperature ramp rate in the range of from 0.2°F/min. to 0.4°F/min., and taking the cast object from a sixth temperature to a seventh temperature in the range of from 2190°F to 2675°F at a temperature ramp rate in the range of 0.15°F/min. to 0.25°F/min.

21. A process according to claim 20, wherein the solution heat treating step further comprises holding the cast object at said

seventh temperature for a time period in the range of 5 hours to 6.5 hours, decreasing the temperature of said cast object from said seventh temperature to an eighth temperature in the range of from 1975°F to 2425°F at a cool down rate of 0.9°F/min. to 1.1 F/min., and decreasing the temperature of said cast object from said eighth temperature to room temperature at a minimum cooling rate in the range of from 100°F/min. to 125°F/min.

22. A process according to claim 12, wherein said forming fine  $\gamma'$  particles step comprises precipitation heat treating the cast object by heating the cast object to a treatment temperature in the range of from 1175°F to 1450°F, holding the cast object at said treatment temperature for a time period in the range of 20 hours to 30 hours, and then air cooling the cast object.

23. A process according to claim 22, wherein said heat treating step comprises heating the cast object to a temperature in the range of from 1200°F to 1400°F and holding the cast object at said treatment temperature for a time period in the range of 22 hours to 26 hours.

24. An object formed from a single crystal nickel base alloy having a microstructure which is pore-free and eutectic  $\gamma - \gamma'$  free and which has a gamma prime morphology with a bimodal  $\gamma'$  distribution.

25. An object according to claim 24, wherein the bimodal  $\gamma'$  distribution includes large  $\gamma'$  particles having an average particle size in the range of from 1 $\mu$  to 20 $\mu$  and fine  $\gamma'$  particles having an average particle size in the range of from 0.45 $\mu$  to 0.55 $\mu$ .

26. An object according to claim 24, wherein said nickel base alloy has a composition comprising 3.0 to 12 wt% chromium, up to 3.0 wt% molybdenum, 3.0 to 10 wt% tungsten, up to 5.0 wt% rhenium, 6.0 to 12 wt% tantalum, 4.0 to 7.0 wt% aluminum, up to 15 wt% cobalt, up to 0.05 wt% carbon, up to 0.02 wt% boron, up to 0.1 wt% zirconium, up to 0.8 wt% hafnium, up to 2.0 wt% niobium, up to 1.0 wt% vanadium, up to 0.7 wt% titanium, up to 10 wt% of at least one element selected from the group consisting of ruthenium, rhodium, palladium, osmium, iridium, platinum, and mixtures thereof, and the balance essentially nickel.